

Specification



## ELECTRONIC COMPONENT COMPRISING A MULTILAYER SUBSTRATE AND CORRESPONDING METHOD OF PRODUCTION

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The invention relates to an electronic component or module having a chip component, especially a filter, and a multi-layer substrate, as well as a process for assembly of the chip component on the multi-layer substrate.

10 An electronic module is a highly-integrated component, which comprises one or more circuits monolithically integrated into a multi-layer substrate and fulfills various functions, in the terminal device of a mobile communication system, for example.

15 An electronic module can, for example, perform the function of an antenna circuit, a duplexer, a diplexer, a coupler, etc.

In addition to the integrated circuits, a module can contain one or more chip components as well as discrete circuit elements or components, which are disposed with the integrated circuit elements on the upper side of the multi-layer substrate.

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It is frequently necessary to obtain a symmetrical signal at the output end of a chip component. To this end, either a balun can be integrated directly into the structure of the chip component, or a chip component having asymmetrical inputs and outputs and a

downstream balun comprising discrete individual elements can be used. Such a balun can be executed as a compact, individual component.

To achieve a higher degree of integration, it is possible to arrange the chip component having upstream and downstream functional units on a shared dielectric substrate. In this manner, front end modules for time-duplexed systems such as 5 GSM900/1800/1900 can be obtained, for example, when SAW filters (SAW = surface acoustic wave) are disposed on a multi-layer ceramic substrate together with the circuit elements of an antenna circuit. In this regard, the circuit elements of the antenna circuit 10 can be partially integrated in the multi-layer substrate.

To achieve optimal signal transmission in the range of the pass band, it is necessary that the output impedance of a chip component be perfectly adjusted to the input impedance of the subsequent stage and/or that the input impedance of a chip 15 component be perfectly adjusted to the output impedance of the upstream stage. Thus, to allow for their adjustment to their circuit environment, the chip components require an electric adjustment network. Such a network can comprise inductances, capacities and delay lines, and its principal purpose is to adjust the impedance of a component to the external environment. It is known that an adjustment network can be executed, wherein 20 the chip component, together with the discrete individual components, is soldered to a printed circuit board.

It is known that an SAW component having a multi-layer carrier substrate (made of ceramics, for example), which comprises integrated adjustment elements, can be attached and electrically connected by means of a flip-chip array or by means of wire bonding. See, for example, document US 5,459,368. In addition to one or more SAW chips, additional passive or active, discrete circuit elements can be disposed on the upper side of the carrier substrate. However, the production of such components is complex and expensive, because SAW chips and/or so-called circuit elements are electrically connected with the carrier substrate by means of various connection methods.

If, for example, a chip component is connected in a reception branch in front of one or between two LNAs (low noise amplifier), the terminal impedance values that occur usually range between 50 and 200 Ohm. If the impedances of the upstage and downstage stages are known, it is essentially possible to execute the chip component in such a way that its input and/or output impedances correspond to the required values. In previously known chip components, the entire component had to be completely redeveloped for each application with the predetermined input and/or output impedance (e.g., 25, 50, 200 Ohm).

However, the range of available terminal impedances for components is often limited (especially in the case of SAW components).

External impedance converters equipped with discrete individual components can also be used. In the latter case, this results in an increase in space requirements. In addition, the reliability of the overall design suffers as a result of the required connection points.

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The goal of the present invention is to provide a highly-integrated component, which comprises a chip component, a multi-layer substrate electrically connected to it, and an impedance converter.

10 This goal is achieved, according to the invention, by means of a component with the features of Claim 1. Advantageous further developments of the invention are found in the additional claims.

15 The invention provides an electronic component, which comprises a) a multi-layer substrate, b) at least one chip component having external contacts, and c) at least one impedance converter (monolithically) integrated into the multi-layer substrate. At least one chip component is disposed on the upper side of the multi-layer substrate and is electrically connected with the impedance converter.

20 A chip component is defined as a "naked" chip having electronic structures or an embedded chip having such structures.

An impedance converter is defined, within the meaning of the invention, as an electronic circuit which fulfills an impedance transformation, that is, which changes actual impedance values characteristic for a chip component or for all chip components of the same type to a predetermined reference value. At issue are not just significant differences between actual and reference impedance values (e.g., a multiplication of impedance from 5 50 to 200 Ohm), but also relatively small differences of less than 100%, but at least 5% between actual and reference impedance values (e.g., a change in impedance from 46 to 50 Ohm). In contrast, in the present <sup>applicable</sup> an adjustment or impedance adjustment is defined as a desired change in impedance of no more than 5%, that is, offsetting a 10 production-related defective adjustment.

An advantage of the component according to the invention is that the impedance converter required for an impedance transformation, in contrast to known solutions, is not disposed on a printed circuit board, but instead is integrated in the multi-layer substrate, 15 wherein the same multi-layer substrate bears a chip component. The total space requirement is especially small in this arrangement, because the integration takes place in a vertical direction. A compact unit encompassing the multi-layer substrate having the integrated impedance converter guarantees the required impedance transformation and can be pre-manufactured by standard means. This unit can easily and quickly transform the 20 characteristic actual impedance of chip components manufactured by standard means to a different required output impedance value. This eliminates the need for new development of the entire chip component, as well as the associated costs and time loss.

In an advantageous embodiment, the component according to the invention can also comprise one or more discrete passive or active circuit elements. In this case, said circuit elements are disposed on the upper side of the multi-layer substrate.

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The discrete passive or active circuit elements can form at least a part of the following circuits: a high-frequent circuit, an adjustment circuit, an antenna circuit, a diode circuit, a transistor circuit, a high-pass filter, a low-pass filter, a band-pass filter, a band elimination filter, a power amplifier, a pre-amplifier, an LNA, a diplexer, a duplexer, a coupler, a directional coupler, a memory element, a balun, a mixer or an oscillator.

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The integrated circuit elements can, for example, establish electric connections between an antenna and the band pass filters in the reception or transmission path of a component according to the invention constructed as a diplexer and, furthermore, improve upon electric filter characteristics in general and, in particular, insulate the reception and

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The integrated circuit elements are preferably disposed in a multi-layer ceramic material, such as LTCC ceramics (= low temperature cofired ceramics). LTCC material allows for a high integration density of network elements. Alternatively, a multi-layer substrate can comprise layers of HTCC (= high temperature cofired ceramics), silicone

and other semiconductors (e.g., GaAs, SiGe, silicone oxide, other oxides) or organic materials (e.g., laminates, plastic).

The multi-layer substrate has both internal electric terminals on the upper side, for contacting the chip component, of which there is generally one, and, if applicable, the discrete circuit element, of which there is generally one, as well as external electrodes on the lower side, to establish an electric connection between the component and an external printed circuit board, such as that of a terminal device.

In the following, the invention is explained in greater detail on the basis of exemplary embodiments and the corresponding figures. The figures are provided for explanatory purposes only and are not true to scale. Identical elements are identified with the same reference numbers.

Figure 1 shows the basic structure of a component according to the invention in schematic cross-section (Figure 1a), as well as a top view of a component according to the invention (Figure 1b).

Figure 2 shows an advantageous embodiment of a component according to the invention, having an integrated coil and an integrated capacitor.

The component shown in Figure 1a is constructed as a multi-layer component having a multi-layer substrate MS, at least one chip component CB being disposed on the

lower side of the multi-layer substrate. The chip component can be either a "naked" chip having electronic structures or a chip having a housing GE. It is possible that the chip component also contains a multi-layer substrate having integrated passive or active circuit elements.

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Within the meaning of the invention, a passive or active circuit element is defined, in particular, as an inductance, a capacity, a delay line, a resistor, a diode or a transistor. In addition, a discrete passive or active circuit element can comprise any combination of the above-mentioned passive or active components in a compact component.

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The chip component formed as a "naked" chip can be attached to the multi-layer substrate or electrically connected with the circuit elements integrated therein by means of bonding wire or flip-chip technology. The external contacts AE of a chip component can also be SMD contacts (SMD = surface mounted design/device).

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The chip component can comprise one or more resonators operating with surface acoustic waves and/or bulk acoustic waves, known as SAW and/or BAW resonators or FBAR (SAW = surface acoustic wave, BAW = bulk acoustic wave, FBAR = thin film bulk acoustic wave resonator).

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The chip component can be a chip having one or more filter circuits (filter chip), for example, SAW components such as SAW filters, BAW filters, LC chip filters, stripline filters or microwave ceramic filters.

5       The at least one chip component CB is electrically connected with an impedance converter IW integrated in the multi-layer substrate MS. The multi-layer substrate can also contain at least one additional integrated circuit element. Another possibility consists in a plurality of said integrated circuit elements forming a part of the following circuits: a high-frequency circuit, an adjustment circuit, an antenna circuit, a diode circuit, a  
10      transistor circuit, a high-pass filter, a low-pass filter, a band-pass filter, a band elimination filter, a power amplifier, an LNA, a pre-amplifier, a diplexer, a duplexer, a coupler, a directional coupler, a memory element, a balun, a mixer or an oscillator.

In this regard, the integrated circuit elements are preferably formed, in a manner known in the art, as strip conductors or randomly shaped metal surfaces in, on or between the individual layers of the multi-layer substrate (substrate layers), as vertical feedthroughs DK in the multi-layer substrate, or as a combination of these elements. It is possible that a part of the integrated circuit elements - that is, at a part of an adjustment circuit - is formed on the upper side of the multi-layer substrate for later fine-tuning by means, for example, of the partial removal of the existing strip conductors or by means of the subsequent addition of discrete circuit elements.  
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A plurality of the chip components disposed on the upper side of the multi-layer substrate can either have a shared impedance converter and/or a shared adjustment circuit or individual impedance converters and/or individual adjustment circuits.

5       The multi-layer substrate can contain, for example, layers of ceramic, silicone, oxides (e.g., silicone dioxide) or organic materials.

The external electrodes AE1 of the component according to the invention on the lower side of the multi-layer substrate can constitute SMD contacts.

10      In addition, at least one discrete passive or active circuit element SE is visible on the lower side of the multi-layer substrate in Figure 1a.

15      Figure 1b shows a top view of a component according to the invention having two chip components CB1 and CB2 and three discrete circuit elements SE1, SE2 and SE3. The discrete circuit elements contain electrodes EL.

20      A component according to the invention can have one or more signal inputs and/or outputs, wherein each individual signal input and/or signal output can be symmetrical or asymmetrical. In the case of symmetrical signal inputs and/or signal outputs, a coil and/or a capacitor between the two symmetrical signal lines may be added as additional basic elements.

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In a further advantageous embodiment, a sheathed chip component (for example, a SAW chip, referred to in the following as a SAW filter) is disposed on the surface of a multi-layer substrate (for example, an LTCC or HTCC multi-layer ceramic) having an integrated impedance converter. The impedance converter comprises a series inductance, which is connected to the output of the chip component and/or of the SAW filter and connects it with an external electrode on the lower side of the multi-layer substrate. The external electrode is used to solder the complete component to a printed circuit board. The series inductance is achieved by means of structured strip conductors and/or strip conductor segments LA (as indicated in Figure 2), which are disposed below an electric contact (external electrode of the chip component) suitable for soldering the chip component and/or the SAW filter. The strip conductors are separated from one another by dielectric layers of the multi-layer substrate. In this regard, the strip conductors of the individual conductor levels LE indicated to the left in Figure 2 are connected with one another by means of feedthroughs DK1, so that a continuous coil winding results. In this regard, the chip component and/or the SAW filter is preferably disposed in such a way that its output electrode is located directly above the external electrode AE1 on the lower side of the multi-layer substrate. In a chip component operating with acoustic waves, the coil winding is preferably disposed underneath the chip component in such a way that it is not located directly below active filter structures of the chip component, otherwise, unwanted electromagnetic couplings would arise, which impair the electric component characteristics. For this reason, other integrated components of the impedance converter,

especially in the uppermost layers of the multi-layer substrate, should be disposed, if possible, below the external contacts of the chip component and not below active structures of the chip component.

5       A ground shield GS located in the lowermost layer of the multi-layer substrate forms a capacity for the windings of the series inductance disposed above it, which constitutes an integrated coil. As a result, mirror currents are induced, which reduce the inductance value of the integrated coil. Larger inductance values can be achieved by maintaining a relatively large distance (e.g., at least 150 µm with strip conductors that are 10      100 µm wide) between the coil and the lower shield layer.

In the embodiment of the component according to the invention shown in Figure 2, its output impedance can be transformed from a higher to a lower impedance value. The underlying circuit comprises a series inductance (coil) connected to the output of the chip component and a capacitor to ground. The capacitor to ground is constructed as follows: 15      A line is branched off at the terminal of the coil on the side of the chip component, this line being, for the most part, formed with feedthroughs DK1, so that this line progresses vertically downward in the multi-layer substrate and, at its end, contacts a metal plate MP, which is separated from the ground shield layer GS by only one dielectric layer, for example, forming a capacitor with the latter. The element identified by the reference 20      symbol K is used here for explanatory purposes only.

In another advantageous embodiment of the invention, the chip component has a symmetrical output. The two contacts of the symmetrical output are preferably disposed directly and/or symmetrically above the corresponding external electrode on the lower side of the multi-layer substrate. The integrated coils, e.g., series coils, which are part of the integrated impedance converter, can be symmetrically or offset symmetrically coiled.

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It is possible that a capacitor executed in the multi-layer substrate is connected between the two contacts of the symmetrical output of the chip component. In this regard, said contacts are connected with parallel metal plates disposed in lower layers by means 10 of feedthroughs.

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In another embodiment, an integrated impedance converter can contain a coil connected to ground. In this regard, one end of the coil is connected, on the one hand, to a ground shield surface, which, for example, is disposed in one of the lower layers of the 15 multi-layer substrate, and, on the other hand, to an external electrode of the chip component by means of a feedthrough.

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It is possible that the at least one chip component CB disposed on the upper side of the multi-layer substrate is mechanically stabilized with one or more circuit elements SE by means of a casting compound, such as Globtop, e.g., with casting resin in an epoxy base.